SECTION 1-D
REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)
INTRODUCTION

Information concerning the RUSLE equation may be found at http://www.sedlab.olemiss.edu/rusle. In addition, conservation planners are encouraged to consult the NRCS National Agronomy Manual (NAM). It can be found at http://policy.nrcs.usda.gov/scripts/lpsiis.dll/M/M.htm.

This section describes the use of RUSLE. RUSLE is a management tool for estimating sheet and rill erosion from rainfall. The equation may be used for estimations from cropland, pastureland, woodland, idle land, and in some cases, urban areas. It quantifies the effects of natural factors, cultural, management, and cropping practices on soil loss. NRCS has determined the allowable soil loss for soil types (mapping units) found in Maryland. These tolerable (T) soil loss figures are based on empirical data for maintaining long term economic productivity and resource sustainability. Values for allowable soil loss for different soil types may be found in Section II of the Field Office Technical Guide (FOTG) or eFOTG. The "T" value represents a comprehensive analysis of all the soil and field conditions. A completely effective erosion control system is one where the necessary water control practices are planned and installed and the soil loss is reduced to or less than the tolerable soil loss (T value).

RUSLE DEFINITION & EXPLANATION

RUSLE estimates average annual soil loss, expressed as mass per unit area per year, which is defined as the amount of sediment delivered from the slope length assumed in the RUSLE computation. RUSLE is a sediment yield equation that describes sediment yield at the end of the *RUSLE slope length*. RUSLE uses a particular set of definitions and observance of these definitions is critical to getting accurate results.

The *RUSLE slope length* is defined according to the problem being addressed. The typical application for RUSLE is development of a conservation plan to protect the eroding portion of a landscape from being excessively degraded by soil erosion, that is, to protect the soil as a resource. In this application, slope length is defined as the distance from the origin of overland flow along the flow path to the point where deposition begins to occur on concave slopes or to a concentrated flow channel. In some cases, the slope can flatten to cause deposition and then become steeper so that erosion occurs on the lower portion of the slope. Slope length passes through the depositional area when soil loss is being estimated on the lower portion of this slope.

Another application of RUSLE is to estimate the amount of sediment leaving a landscape that may cause off-site damages such as sedimentation in a road drainage ditch. In this case, the slope length is the distance from the origin of overland flow through depositional overland flow areas to the first "concentrated flow" area that collects the overland flow to the point that the runoff can no longer be considered overland flow. Consideration outside of RUSLE must be given to deposition that occurs in concentrated flow areas, except terrace and diversion channels that are considered by RUSLE, to fully estimate sediment yield from a landscape area.

RUSLE also computes soil loss for individual slope segments. These soil loss values represent net sediment production for those segments, which is the net between detachment and deposition within the segment.

THE RUSLE EQUATION

RUSLE is an index method having factors that represent how climate, soil properties, topography, and land use affect sheet and rill (not ephemeral or classic gullies as concentrated flow channels) soil erosion caused by raindrop impact and surface runoff. In general, erosion depends on the:

- Amount and intensity of rainfall and runoff;
- Protection provided to the soil by land use against the direct forces of raindrop impact and surface runoff,
- Susceptibility of soil to erosion as a function of intrinsic soil properties and soil properties modified by land use, and
- Topography of the landscape as described by slope length, steepness, and shape.

These influences are expressed in the Revised Universal Soil Loss Equation (RUSLE) as:

A = R*K*LS*C*P where;

A is the predicted soil loss
R is the rainfall factor
K is the soil erodibility factor
LS is the slope length and gradient factor
C is the cropping management factor
P is the erosion control practice factor

RUSLE is a lumped process model that is based on the analysis of a large mass of experimental data. Rather than explicitly representing the fundamental processes of detachment, deposition, and transport by rainfall and runoff, RUSLE represents the effects of these processes on soil loss.

RUSLE FACTOR DEFINITIONS

A:

"A" is the computed soil loss per unit area. It is expressed as tons per acre per year. When "A" is computed, compare the value with acceptable soil loss values "T" to determine soil erosion control practices needed. The "T" values are maximum allowable soil losses in tons per acre per year.

R Factor:

The R factor represents the erosivity of the climate at a particular location. An average annual value of R is determined from historical weather records and is the average sum of the erosivity of individual storms. The erosivity of an individual storm is computed as the product of the storm's total energy, which is closely related to storm amount, and the storm's maximum 30-minute intensity.

The rainfall factor (R) for the counties in Maryland are shown in the posted R factor map and table posted under climatic information.

K Factor:

The K factor is an empirical measure of soil erodibility as affected by intrinsic soil properties. It is the rate of erosion per unit of erosion index from unit plots on a given soil. A unit plot is 72.6 feet long and has a uniform lengthwise slope of nine percent. Unit plots are kept in continuous fallow and freed of vegetation for at least two years or until all crop residue has decomposed before they are used to determine K factors. When measurements are made, the plots are plowed in the spring and prepared for planting corn by conventional methods. Additional tillage may be used to control vegetation and prevent crusting. All tillage operations are performed up and down the slope. These losses are the basis for determining K factors.

More than 25 characteristics of a soil affect its response to water erosion. These characteristics are grouped into two categories: 1) those that influence infiltration, permeability, and total water holding capacity; and, 2) those that affect dispersion, splashing, abrasion, and transportation of soil particles by surface water runoff. The original K factors reflected the erodibility of the surface layer. Increased interest in soil losses from construction sites has stimulated the determination of K factors for other layers as well. Soil series now have several K factors depending on the profile characteristics in an effort to address sub-surface soil erodibility.

K factors are adjusted for seasonal changes in climate such as freezing and thawing or consolidation. A map of climate zones for Maryland is located in the posted Climatic Information section. The climate adjusted soil erodibility factors (K) are shown in the posted K factor table.

LS Factor:

LS is the topographic factor in the equation. L is the length of slope in feet and S is the percentage of slope. Even though the L and S have independent effects on water erosion, in this equation they are considered together as the soil loss ratio, or LS factor.

RUSLE represents the combined effects of sheet and rill erosion. Rill erosion is primarily caused by surface runoff and increases in a downslope direction because runoff velocity also increases in the downslope direction. Sheet erosion is caused primarily by raindrop impact and is uniform along a slope. Therefore, the L factor is greater for those conditions where rill erosion tends to be greater than sheet erosion.

Erosion increases with slope steepness, but in contrast to the L factor for the effects of slope length, RUSLE makes no differentiation between sheet and rill erosion in the S factor that computes the effect of slope steepness on soil loss.

Slope shape is a variation of slope steepness along the slope. Slope steepness and position along the slope interact to greatly affect erosion. Soil loss is greatest for convex slopes that are steep near the end of the slope length where runoff rate is greatest and least for concave slopes where the steep section is at upper end of the slope where runoff rate is least.

The LS factor is a measure of sediment production. Deposition can occur on concave slopes where transport capacity of the runoff is reduced as the slope flattens. This deposition and its effect on sediment yield from the slope is considered in the supporting practices P factor.

NOTE: Determination of the L and S factors can be very difficult even for well trained conservation planners, agronomists, or engineers. The factors have significant impact on the predicted soil loss. As such, conservationists must carefully measure the on-site conditions that best represent the field conditions. Slope length of L is sometimes confused with field slope length. This can be avoided if the slope under consideration meets these criteria:

- It begins where surface water runoff starts.

- It ends where the slope decreases and deposition of soil particles begins, or the surface water runoff enters a well-defined channel.
- It is the horizontal interval between terraces.
- It includes the entire field slope length in contoured or contour strip-cropped fields without terraces or diversions.

The LS factors may be obtained for counties in Maryland on the posted LS factor table.

C Factor:

The C factor for the effects of cover management is one of the most important factors in RUSLE because it represents the effect of land use on erosion. It is the single factor most easily changed and is the factor most often considered in developing a conservation plan. For example, the C factor describes the effects of differences between vegetation communities, tillage systems, and addition of mulches.

The C factor is influenced by:

- *Canopy* (cover above but not in contact with the soil surface),
- *Ground cover* (cover directly in contact with the soil surface),
- *Surface roughness, time since last mechanical disturbance, amount of live and dead roots in the soil*, and
- *Organic material that has been incorporated into the soil.*

These variables change through the year as plants grow and senesce, the soil is disturbed, material is added to the soil surface, and plant material is removed. The C factor is an average annual value for soil loss ratio, weighted according to the variation of rainfall erositivity over the year. The average annual distribution of erosivity during a year is concentrated in late fall and early winter in the Northeast region. Soil resources also experience significant runoff and sedimentation from intense, short duration storms during the growing season.
The selection of numerous management techniques that affect the C value affords the planner an almost unlimited selection of management alternatives that can be incorporated into cropping systems. However, operator limitations including (1) management abilities or constraints; (2) acceptance of new technology; and (3) equipment availability may significantly limit viable alternatives. In addition to soil loss, the planner must keep in mind crop management techniques as they related to integrated pest management and nutrient management. Examples include the use of specific crop sequences to avoid specific weed, disease or insect problems; the use of cover crops for fall applied manure and the consideration of tillage methods and utilization of nutrients from manure.

The posted C Factor PDF file contains tables of C values for the most common crops using various cultivations.

P Factor:

The supporting practice (P) factor describes the effects of practices such as contouring, strip cropping, concave slopes, terraces, diversions, and sediment basins. These practices are applied to support the basic cultural practices used to control erosion that are represented by the C factor. Supporting practices typically affect erosion by redirecting runoff around the slope to a safe outlet so that it has less erosivity or slowing the runoff to cause deposition such as concave slopes or barriers like vegetative strips and terraces.

The major factors considered in estimating a P factor value include runoff rate as a function of location, soil, and management practice; erosivity and transport capacity of the runoff as affected by slope steepness and hydraulic roughness of the surface; and sediment size and density.

The posted P Factor PDF file contains the necessary information to obtain the P value for various practices.

LIMITATIONS OF RUSLE

RUSLE predicts long-term average annual soil loss carried by runoff from specific field slopes under specified cover and management systems. It is substantially less accurate for the prediction of specific erosion events associated with single storms and short-term random fluctuations.

RUSLE also estimates sediment yield for eroded soil leaving the end of a slope with certain support practices. It does not predict sediment yield for the amount of sediment that is delivered to a point in a watershed, such as the edge of a field, that is remote from the origin of the detached soil particles. Nor does RUSLE predict erosion that occurs in concentrated flow channels.

The paper version of RUSLE includes information for the typical crops and crop rotations within the state. Field Offices should contact the state agronomist for assistance in developing RUSLE factors for situations not included in the paper version of RUSLE.

The **RUSLE2** computer program is not available for Field Office use at this time. This interim paper version of RUSLE will be used for all conservation planning and technical assistance until the RUSLE2 program is installed in the Field Offices and posted on this website. RUSLE2 will be implemented by **Fall 2003**, at which time we will cease using this interim paper version.